DIFFERENTIAL UNIT

BACKGROUND OF THE INVENTION

Technical Field

The present invention relates to a differential unit.

Related Art

Generally, in a drive system for an automobile, a differential unit is used in order to change a transmitting direction of a drive power by ninety degrees, and to carry out a final gear reduction and a differential function.

In the differential unit of the related art, as shown in Fig. 6, the differential unit 101 is provided with a drive pinion shaft 109 and a drive pinion (bevel pinion) meshing with a driven gear (not shown) at one end in a case 105 formed by a differential carrier 103 and a differential cover (not shown). The driven gear is rotatably supported in the differential carrier 103 by a differential mechanism (not shown) attached to the driven gear and by bearings (not shown), and mechanically connected to drive axles (not shown) for left and right wheels through the differential mechanism.

The drive pinion shaft 109 is rotatably supported on the differential carrier 103 by three bearings 113, 115 and 117. A companion flange 119 for linking the drive shafts (not shown) such as propeller shafts is fixed to another end of the drive pinion shaft 109 by spline fitting by using a nut 121. Cylindrical spacers 123 and 125 are interposed between inner races 113a, 115a and 117a of the three bearings 113, 115 and 117 as rotatably mounted on the drive pinion 109 in order to regulate attachment positions of the respective bearings 113, 115 and 117. The spacers 123 and 125 integrally rotate with the drive pinion shaft 109 interposed between the bearings 113, 115 and 117.

However, in the differential unit of the related art, an internal diameter of the spacers 123 and 125 is set to a larger value than that of the outer diameter of the drive pinion shaft 109 because the spacers 123 and 125 are rotatably mounted on the drive pinion 109. For this reason, the

rotational center of the drive pinion shaft 109 does not match exactly with the rotational centers of the spacers 123 and 125. And when the spacers 123,125 are interposed between the bearings 113, 115 and 117, there is a possibility that the rotational center C1 of the drive pinion shaft 109 does not match the rotational center C2 of the spacers 123 and 125.

If the spacers are interposed between the spacers in this way with the rotational center of the drive pinion shaft is offset from that of the spacers, the spacers become unbalanced components and imbalance arises with respect to the drive pinion shaft. For example, in the case where the mass of a spacer is set to 300g and a difference between the internal diameter of the spacer and the external diameter of the drive pinion shaft is set to 1 mm, the maximum positional offset between the rotational center of the drive pinion shaft and that of the spacer is 0.5 mm, and a maximum imbalance of 15 gcm arises.

Because the spacers rotate integrally with the drive pinion shaft, vibrations will arise in the differential unit due to the above described imbalance if the drive pinion shaft rotates, and these transmission vibrations affect vehicle body vibrations.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a differential unit that is capable of reducing an imbalance with respect to a drive pinion shaft.

A differential unit of a first aspect of the present invention is provided with a spacer penetrated in said drive pinion shaft for restricting an installing point of the bearings in the case; and restricting means provided between the spacer and the drive pinion shaft for preventing an irregular gap therebetween in a radial direction so as to avoid a rotational eccentricity of the spacer and the drive pinion shaft and a vibration transmitting to the motor vehicle.

With this differential unit, since there is restricting means for preventing an irregular gap therebetween in a redial

direction so as to avoid a rotational eccentricity of the spacer and the drive pinion shaft and a vibration transmitting to the motor vehicle. As a result, it is possible to reduce imbalance with respect to a drive pinion shaft.

A differential unit of a second aspect of the invention, the restricting means is integrally formed in the spacer.

A differential unit of a third aspect of the invention, the restricting means is separately provided between the spacer and the drive pinion.

The above and other objects, features and advantages of the present invention will become clear from the following description of the preferred embodiments thereof, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic cross sectional drawing showing a differential unit of the present invention.

Fig. 2 is the schematic cross sectional drawing showing essential parts of the differential unit shown in Fig. 1.

Fig. 3 is the schematic cross sectional drawing showing a modified example of the differential unit of the present invention.

Fig. 4 is the schematic cross sectional drawing showing the essential parts of the modified example of the present invention.

Fig. 5 is the schematic cross sectional drawing showing the essential parts of the modified example of the present invention.

Fig. 6 is the schematic cross sectional drawing showing a differential unit of the prior art.

Fig. 7 is the cross sectional view of a drive pinion shaft and a spacer shown in Fig. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of a differential unit of the present invention will be described in detail by referring the following drawings. Omitted are the same reference

numerals and repeated description.

First, an embodiment of the differential unit according to the present invention will be described with reference to Figs. 1 and 2. Fig. 1 is a schematic cross sectional drawing showing a differential unit of the embodiment, and Fig. 2 is a schematic cross sectional drawing of essential elements thereof shown in Fig. 1.

As shown in Fig. 1, the differential unit 1 is enclosed in a case 5 with a differential cover (not shown) attached to an opening section of a differential carrier 3. A drive pinion shaft 9 is inserted into the inside of the case 5. A drive pinion (bevel pinion) 11 integrally formed on one end of the drive pinion shaft 9 and a driven gear (not shown) then engage with each other. A differential mechanism case (not shown) is attached to the driven gear with bolts (not shown), and the driven gear is rotatably supported by the differential mechanism case and the differential carrier 3.

The drive pinion shaft 9 is rotatably supported on the differential carrier 3 by a single pilot bearing 13 and a pair of tapered roller bearings 15 and 17. A companion flange 19 for linking drive shafts (not shown) such as propeller shafts is spline fitted to the other end of the drive pinion shaft 9, and is fixed by press fitting to an inner race 13a of the pilot bearing 13 by the fastening force of a nut 21. In this way, the companion flange 19 is provided on an input axis end of the differential unit 1. The inside of the differential carrier 3 is airtightly sealed by an oil seal 23 provided between the differential carrier 3 and the companion flange 19.

Cylindrical spacers 25 and 27 are respectively interposed not only between the inner race 13a of the pilot bearing and an inner race 15a of the front side tapered roller bearing 15 but also between the inner race 15a of the front side tapered roller bearing 15 and an inner race 17a of the rear side tapered roller bearing 17 on the drive pinion shaft 9. The spacers 25 and 27 restrict attachment positions of the pilot bearing 13 and the tapered roller bearings 15 and 17.

An axial force applied to the companion flange 19 by the nut 21 acts on the inner race 15a of the front side tapered roller bearing 15 through the inner race 13a of the pilot bearing 13 and the spacer 25. On the other hand, the axial force applied to the drive pinion shaft 9 by the nut 21 acts on the inner race 17a of the rear side tapered roller bearing 17 through the drive pinion 11. In this way, axial forces in mutually opposite directions respectively acting on the inner races 15a and 17a of the two tapered roller bearings 15 and 17 are received on the one hand by the spacer 27 and adjustment washer 29 interposed between the two inner races 15a and 17a, and received on the other hand by the differential carrier 3 through the respective rollers 15b and 17b and the outer races 15c and 17c. As a result, a precompression force of the same magnitude is supplied to the two tapered roller bearings 15 and 17. The bearing rigidity of the drive pinion shaft 9 is then increased due to this precompression force. And a relative offset between the drive pinion 11 and the driven gear when applied at a load is decreased. Accordingly it becomes possible to maintain an appropriate gear engagement.

In this embodiment, as shown in Fig. 2, a protruding section 31 (position regulating means) protrudes towards the drive pinion shaft 9 at an inner side section facing the drive pinion shaft 9. And the protruding section 31 is integrally formed on the front side spacer 25 interposed between the inner races and 15a. The protruding section 31 is formed in a curved shape so as to be generally convex along the overall central axial direction of the spacer 25, and the cross sectional shape is arched. Also, as the protruding section 31 protrudes towards the drive pinion shaft 9 along the entire inner peripheral direction of the spacer 25 (outer peripheral direction of the drive pinion shaft 9), the inner surface of the protruding section 31 comes into contact with or close to the outer surface of the drive pinion shaft 9. In this way, as the inner surface comes into contact with or close to the outer surface of the drive pinion shaft 9, the rotational centers of the drive pinion shaft 9 and the spacer 25 become

substantially aligned, there is little positional offset between there.

In this embodiment, since the protruding section 31 facing the drive pinion shaft 9 is provided as position regulating means, the positional offset therebetween is reduced by the protruding section 31, the spacer 25 is prevented from becoming an unbalanced element. As a result, it is possible to decrease imbalance arising with respect to the drive pinion shaft 9.

Also, since the protruding section 31 is provided integrally with the spacer 25, there is no need to provide new components as the positional regulating means, and it becomes possible to reduce the numbers of components and assembly steps. As a result, it is possible to simply minimize the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 at low cost.

Next modified example will be described by referring to Fig. 3. Fig. 3 is a schematic cross sectional drawing showing essential elements in the modified example. The example shown in Fig. 3 and the embodiment shown in Fig. 2 are different with respect to the shape of the protruding section 31.

As shown in Fig. 3, a protruding section 41 is integrally provided at a specified position in the central axial direction of the spacer 25. For example, the protruding section 41 is at a substantially central position in the central axial direction of the spacer 25. The protruding section 41 is provided to protrude thereof so as to face the drive pinion shaft 9 along the entire inner direction of the spacer 25 (outer direction of the drive pinion shaft 9) in the same way as shown in Fig. 2. The protruding section 41 is positioned between the drive pinion shaft 9 and the spacer 25, and the inner surface thereof comes into contact with or close to the outer surface of the drive pinion shaft 9. In this way, as the inner surface of the protruding section 41 comes into contact with or close to the outer surface of the drive pinion shaft 9, the rotational centers of the drive

pinion shaft 9 and the spacer 25 become substantially aligned, and therefore there is little positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25.

In this embodiment shown in Fig. 3 the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 is also reduced by the protruding section 41, and therefore it can reduce an imbalance arising with respect to the drive pinion shaft 9. Also, since the protruding section 41 is integrally provided with the spacer 25, similarly to the embodiment shown in Fig. 2, it is possible to simply prevent the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 at low cost.

Next modified example will be described based on Fig. 4. Fig. 4 is a schematic cross sectional drawing showing the essential elements in the modified example shown in Fig. 4. The modified example shown in Fig. 4 and the embodiment shown in Fig. 2 are different in that the position regulating means is provided separately from the spacer.

An O-ring 51 (position regulating means) is provided between the spacer 25 and the drive pinion shaft 9 as shown in Fig. 4. The O-ring 51 is arranged in the vicinity of an end section of the spacer 25 close to the tapered roller bearing 13. The O-ring 51 is made from metal or rubber.

The O-ring 51 contacts with the outer surface of the drive pinion shaft 9 and the inner surface of the spacer 25. In this way, the rotational centers of the drive pinion shaft 9 and the spacer 25 become substantially aligned due to the fact that the O-ring 51 contacts with the outer surface of the drive pinion shaft 9 and the inner surface of the spacer 25, and therefore there is little positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25.

In this modified shown in Fig. 4, since there is the O-ring 51 between the spacer 25 and the drive pinion shaft 9 as position regulating means, the positional offset between

the rotational centers of the drive pinion shaft 9 and the spacer 25 is reduced by this O-ring 51, and the spacer 25 is prevented from becoming an unbalanced element. As a result, it is possible to decrease imbalance arising with respect to the drive pinion shaft 9.

Also, since the O-ring 51 is provided separately from the spacer 25, there is no need for design modifications accompanying change in shapes of the spacer 25. And it is simply possible to realize a structure for preventing the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 at low cost.

Next example of the differential unit of this embodiment will be described based on Fig. 5. Fig. 5 is a schematic cross sectional drawing showing essential parts in the modified example of this embodiment. The modified example shown in Fig. 5 and the modified example shown in Fig. 4 are different with regards to the number of O-rings and the positions at which the O-rings are arranged.

O-rings 51 are arranged at two places in the vicinity of an end of the spacer 25 close to the tapered roller bearing 13 and in the vicinity of the end of the spacer 25 close to the tapered roller bearing 15. By thus providing the O-rings 51 in a pair in the vicinity of the two ends of the spacer 25, it is possible to drastically reduce the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25.

In this modified example of this embodiment shown in Fig. 5, since there are a plurality of O-rings 51 (a pair in the vicinity of the two ends of the 25) between the spacer 25 and the drive pinion shaft 9 as position regulating means, the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 is drastically reduced by the O-rings 51. And the spacer 25 is reliably prevented from becoming an unbalanced element.

As a result, it is possible to more drastically reduce the imbalance arising with respect to the drive pinion shaft 9. Also, since the O-rings 51 are provided separately from

the spacer 25 in the same way as to the modified example shown in Fig. 4, it is simply possible to realize to prevent positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 at low cost.

The present invention is not limited to the above described embodiment. For example, a structure is possible having the position regulating means (such as the protruding section 31 or the O-ring 51) between the rear side spacer 27 interposed between the inner races of the pair of the tapered roller bearings 15 and 17, and the drive pinion shaft 9.

Also, in the embodiments shown in Figs. 2 and 3, the protruding sections 31 and 41 are provided so as to protrude towards the drive pinion shaft 9 along the entire inner direction of the spacer 25 (outer direction of the drive pinion shaft 9), but there is no limiting in that way. It is also possible to have the structure with the protruding sections 31 or 41 provided at the specified places on the inner peripheral direction of the spacer 25 (outer peripheral direction of the drive pinion shat 9) at three places spaced 120° apart or at 4 places space 90° apart, as long as the positional offset between the rotational centers of the drive pinion shaft 9 and the spacer 25 is reduced.

Also, the unit provided with the protruding section 31 or 41 is not limited to being positioned substantially centrally in the axial center direction, and it is possible to be positioned at the end of the spacer 25 in a central axial direction. It is possible to provide the protruding sections respectively at both ends of the spacer in the central axial direction.

In the differential unit of the present invention, since there is the position regulating means between the drive pinion shaft and the spacer, the positional offset between the rotational centers of the pinion shaft and the spacer is reduced, and the spacer is prevented from becoming unbalanced. Accordingly, it is possible to provide the differential unit capable of reducing imbalance arising with respect to the drive pinion shaft.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.